

DOWNHOLE TEMPERATURE

Introduction

Temperature measurements are important in the study of the Earth's processes. Data collected by the Ocean Drilling Program (ODP) have been used to study the transfer of heat from the interior, ocean lithospheric evolution, continental margin formation, subduction zones, hotspot volcanism, fluid flow and methane hydrate formation. Most measurements were made between 20 and 250 mbsf; however, a few measurements were taken below 500 mbsf.

Several tools have been used during the ODP to collect borehole and formation temperature data. Tools that have been used during the ODP include: Advanced Piston Corer (APC), Water Sampler Temperature Probe (WSTP), Uyeda Temperature Tool, and the Davis Villinger Temperature Probe (DVTP).

Temperature Data Acquisition

Temperature Tools

The Advanced Piston Corer (APC) tool was a temperature tool compatible with the APC coring system. This tool was first used during the Deep Sea Drilling Project Leg 86. ODP purchased 10 *von Herzen* temperature tools, but all were unusable by Leg 117. The second generation APC temperature tool was often referred to as *Adara* after the company that built and interfaced the tools to a PC computer. The APC tool resided in the APC cutting shoe and measured formation temperature while the APC core was being retrieved. These measurements were usually made down to ~100-150 meters below the seafloor until the coring method switched because of the need to use a different drill bit.

The water sampling temperature probe (WSTP) was a temperature tool compatible with the XCB and RCB coring systems and could be used in formations that were too stiff for APC coring. It was a hybrid of two other tools – the Uyeda Temperature Tool and the Barnes Fluid Sampler. The first generation WSTP tool was actually the Uyeda tool, used until Leg 116. The second generation WSTP was deployed during Leg 110. A third version of the WSTP was deployed On Leg 139. Coring was interrupted in order to take WSTP temperature measurements.

The Davis-Villinger Temperature Probe (DVTP) was designed to take heat-flow measurements in semi-consolidated sediments that were too stiff for APC coring. Coring had to be interrupted in order to take a temperature measurement with DVTP. The DVTP could also be run on wireline and hung below the bit as a temperature logging tool for borehole fluids. The tool was officially deployed during Leg 168.

Temperature Data Reduction

Several data reduction programs were used to determine the *in-situ* temperature during the ODP. It wasn't practical to keep the temperature probe in contact with the sediment or rock for the extended period of time necessary to reach equilibrium. The data reduction programs were used to determine the theoretical curve based on the observed data and infer the equilibrium temperature. Factors that could affect getting a good estimate of temperature included frictional heating of the probe due to insertion, time interval of sampling and *in-situ* thermal conductivity.

Archive

Pre-Janus Archive

Temperature measurements were logged on data sheets that were collected and sent back to ODP/TAMU after the cruise for microfilming and archival. No interim database was found for these data. Digital files were created and stored starting with the APC/Adara tool on Leg 144. After that time, all tools created digital files that have been archived in the ODP/TAMU servers.

Migration of Temperature data to Janus

The data model for Downhole Temperature data can be found in Appendix I. Included are the relational diagram and the list of tables that contain data pertinent to temperature measurements, the column names and the definition of each column attribute. The data model was designed for the APC/Adara tool. An uploader was created and a couple Adara temperature runs were uploaded, but there was too much variability between data files. The format of the data files for the other tools varied significantly from the APC/Adara files. The objective of uploading all the raw data was deferred and not completed during the ODP.

As a result, only the final temperature determined by the Scientific Party was uploaded to Janus. Much of the temperature data were taken from the Initial Reports volumes; however, not all temperature data were analyzed and reported in the Initial Reports, so some temperature measurements are missing from the database.

Janus Downhole Temperature Data Format

Downhole temperatures can be retrieved from Janus Web using a predefined query. The Downhole Temperature query webpage allows the user to extract data using the following variables to restrict the amount of data retrieved: leg, site, hole, core, section, depth range, or latitude and longitude ranges. Table 1 contains the data fields retrieved from the Janus database using the query. The first column contains the data item; the second column indicates the Janus table or tables in which the data were stored; the third column is the Janus column name or the calculations used to produce the value.

Appendix II contains additional information about the fields and the data format for the archived ASCII files.

Table 1. Downhole Temperature query.

Item Name	Janus Table	Janus Column Name
Leg	DHT_APCT_RUN	apct_leg
Site	DHT_APCT_RUN	apct_site
Hole	DHT_APCT_RUN	apct_hole
Core	DHT_APCT_RUN	apct_core
Type	DHT_APCT_RUN	apct_core_type
Top Depth (mbsf)	CORE	top_depth
Bottom Depth (mbsf)	CORE	top_depth + advancement
Depth Comment	DHT_APCT_RUN	apct_depth_comment
Temperature (C)	DHT_APCT_TFIT_RESULTS	apct_best_fit_temp_t0
Error (C)	DHT_APCT_TFIT_RESULTS	apct_best_fit_error_rms
Mudline (C)	DHT_APCT_TFIT_RESULTS	apct_mudline_tem,p
Tool Name	DHT_APCT_CALIB	apct_tool_name
Notes	DHT_APCT_RUN	apct_run_comment

Data Quality

As described above, only the final temperature values determined by the Scientific Parties were uploaded to Janus. Due to time constraints, there was no time to complete the verification of these data. Any questions about downhole temperature data, or requests for raw data should be directed to the IODP Data Librarian [database@iodp.tamu.edu].

References

Davis, E.E., Chapman, D.S., Villinger, H., et al., 1997. Seafloor Heat Flow on the Eastern Flank of the Juan de Fuca Ridge: Data from "Flankflux" Studies Through 1995. In Davis, E.E., Fisher, A.T., Firth, J.V., et al., *Proc. ODP, Init. Repts.*, 168: 23-32, College Station, TX (Ocean Drilling Program).

ODP Staff, 1992, WSTP Cookbook, v.144, (not published).

ODP Staff 1992, Adara Temperature Tool Cookbook, v.146, (not published).

Pribnow, D.F.C., Kinoshita, M., and Stein, C.A., 2000. Thermal data collection and heat flow recalculations for ODP Legs 101-180. Institute for Joint Geoscientific Research, GGA, Hannover, Germany 0120432. Available from World Wide Web: <<http://www-odp.tamu.edu/publications/heatflow/>>.

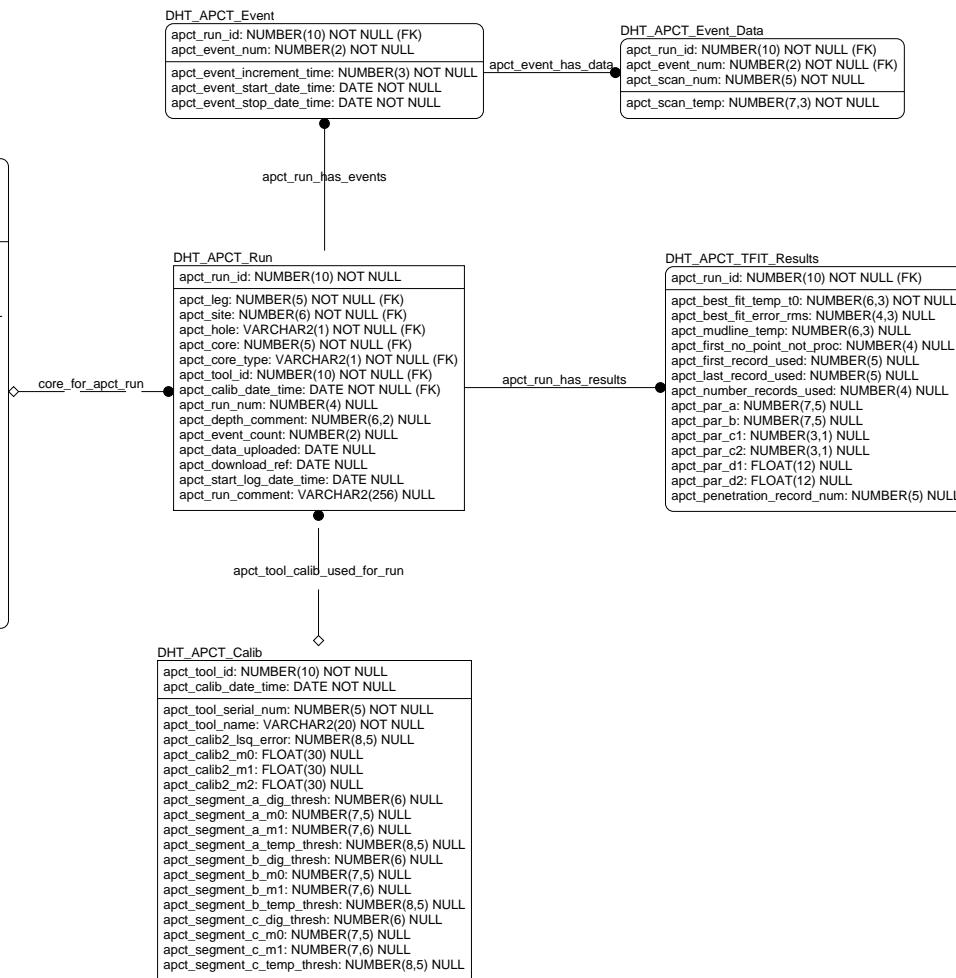
Core

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leg: NUMBER(5) NOT NULL (FK)
site: NUMBER(6) NOT NULL (FK)
hole: VARCHAR2(1) NOT NULL (FK)
Core: NUMBER(5) NOT NULL
core_type: VARCHAR2(1) NOT NULL (FK)

time_on_deck: DATE NULL
entry_timestamp: DATE NULL
meter_comp_depth: NUMBER(6,2) NULL
marine_tech_code: VARCHAR2(60) NULL
marine_tech_comments: VARCHAR2(30) NULL
ops_tech_comments: VARCHAR2(80) NULL
advancement: NUMBER(7,2) NULL
top_depth: NUMBER(8,2) NULL
is_pump1: VARCHAR2(1) NULL
is_pump2: VARCHAR2(1) NULL
wireline_runs: NUMBER(4) NULL
wireline_spool: VARCHAR2(1) NULL
drilling_time: NUMBER(4) NULL
cc1: VARCHAR2(5) NULL (FK)
cc2: VARCHAR2(5) NULL (FK)
cc3: VARCHAR2(5) NULL (FK)
shoe1: VARCHAR2(5) NULL (FK)
shoe2: VARCHAR2(5) NULL (FK)
shoe3: VARCHAR2(5) NULL (FK)
core_liner: VARCHAR2(20) NULL (FK)
orientation_tool: VARCHAR2(20) NULL (FK)
offset: NUMBER(2) NULL
ops_pri_lith: VARCHAR2(30) NULL (FK)
ops_sec_lith: VARCHAR2(30) NULL (FK)
bit_id_null: NUMBER(4) NULL (FK)

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Appendix I. Janus Data Model – Downhole Temperature

DOWNHOLE TEMPERATURE		
Table Name	Column Name	Column Comment
DHT_APCT_Event	apct_run_id	Unique Oracle-generated sequence number to define an APC temperature tool run.
	apct_event_num	The number of an event associated with an APC temperature tool measurement.
	apct_event_increment_time	Increment time of an event for an APC temperature tool, in seconds
	apct_event_start_date_time	Timestamp at start of event.
	apct_event_stop_date_time	Timestamp at the end an APC temperature event.
DHT_APCT_Event_Data	apct_run_id	Unique Oracle-generated sequence number to define an APC temperature tool run.
	apct_event_num	The number of an event associated with an APC temperature tool measurement.
	apct_scan_num	The scan number in an event associated with an APC temperature tool measurement.
	apct_scan_temp	Raw temperature recorded during an event associated with an APC temperature tool measurement, in °C. Will be based on manufacturer values if '*.dat' file used, or WHOI recalibrated values if '*.new' file is used.
DHT_APCT_Run	apct_run_id	Unique Oracle-generated sequence number to define an APC temperature tool run.
	apct_leg	Number identifying the cruise for which data were entered into the database.
	apct_site	Number identifying the site from which the core was retrieved. A site is the position of a beacon around which holes are drilled.
	apct_hole	Letter identifying the hole at a site from which a core was retrieved or data were collected.
	apct_core	Sequential numbers identifying the cores retrieved from a particular hole. Cores are generally 9.5 meters in length, and are numbered serially from the top of the hole downward.
	apct_core_type	A letter code identifying the drill bit/coring method used to retrieve the core.
	apct_tool_id	Unique Oracle-generated identifier for a tool. It is possible for APC temperature tools to have the same identifying number as a previous tool, so unique ID is necessary.
	apct_calib_date_time	Date that the APC temperature probe calibration was entered into the database.
	apct_run_num	Run number associated with an APC temperature tool run.
	apct_depth_comment	This field allows the user to input the depth from the log sheet, but the actual depth will be calculated from Janus using the provided depth calculations. In meters.
	apct_event_count	The number of events recorded for an APC temperature tool run.
	apct_data_uploaded	The Date Uploaded time as recorded in the '*.dat' or '*.new' file
	apct_download_ref	The Download Reference value as recorded in the '*.dat' or '*.new' file.
	apct_start_log_date_time	The start logging time as recorded in the '*.dat' or '*.new' file.
	apct_run_comment	Comment concerning the run.
DHT_APCT_TFIT_Results	apct_run_id	Unique Oracle-generated sequence number to define an APC temperature tool run.
	apct_best_fit_temp_t0	Calculated best fit temperature for an APC temperature tool run, in °C.
	apct_best_fit_error_rms	Best fit error, in °C.
	apct_mudline_temp	Mudline temperature in °C - added on July 9, 2002.
	apct_first_no_point_not_proc	The first APC temperature scan number not processed.
	apct_first_record_used	First record used for a APC temperature tool calculation.

	apct_last_record_used	Last record used for an APC temperature tool calculation.
	apct_number_records_used	Number of measurements used for an APC temperature tool calculation.
	apct_par_a	Parameter A from an APC temperature tool TFIT file.
	apct_par_b	Parameter B from an APC temperature tool TFIT file.
	apct_par_c1	Parameter C1 from an APC temperature tool TFIT file, thermal conductivity of the sediment.
	apct_par_c2	Parameter C2 from an APC temperature tool TFIT file.
	apct_par_d1	Parameter D1 from an APC temperature tool TFIT file.
	apct_par_d2	Parameter D2 from an APC temperature tool TFIT file. Changed from NUM(12) to FLOAT(12), Aug. 2000
	apct_penetration_record_num	Scan number used to determine when penetration of the APC temperature tool occurred.
DHT_APCT_Calib	apct_tool_id	Unique Oracle-generated identifier for a tool. It is possible for APC temperature tools to have the same identifying number as a previous tool, so unique ID is necessary.
	apct_calib_date_time	Timestamp when the APC temperature probe calibration was entered into the database.
	apct_tool_serial_num	The serial number that identified an APC temperature tool probe. This number may not be unique over time.
	apct_tool_name	APC tool name.
	apct_calib2_lsq_error	Least squares error calculated for a calibration of an APC temperature tool probe.
	apct_calib2_m0	The intercept for an APC temperature probe that has been recalculated by WHOI.
	apct_calib2_m1	The slope for an APC temperature probe that has been recalculated by WHOI.
	apct_calib2_m2	The quadratic coefficient of a secondary calibration performed on an APC temperature tool by WHOI.
	apct_segment_a_dig_thresh	The digital threshold for the first segment calibrated for an APC temperature tool probe.
	apct_segment_a_m0	The intercept for the first segment calibrated for an APC temperature tool probe.
	apct_segment_a_m1	The slope for the first segment calibrated for an APC temperature tool probe.
	apct_segment_a_temp_thresh	The temperature threshold for the first segment calibrated for an APC temperature tool probe.
	apct_segment_b_dig_thresh	The digital threshold for the second segment calibrated for an APC temperature tool probe.
	apct_segment_b_m0	The intercept for the second segment calibrated for an APC temperature tool probe.
	apct_segment_b_m1	The slope for the second segment calibrated for an APC temperature tool probe.
	apct_segment_b_temp_thresh	The temperature threshold for the second segment calibrated for an APC temperature tool probe.
	apct_segment_c_dig_thresh	The digital threshold calculated for the third segment of an APC temperature tool probe
	apct_segment_c_m0	The intercept for the third segment calibrated for an APC temperature tool probe.
	apct_segment_c_m1	The slope for the third segment calibrated for an APC temperature tool probe.
	apct_segment_c_temp_thresh	the temperature for the third segment calibrated for an APC temperature tool probe.
Core	leg	Number identifying the cruise for which data were entered into the database.
	site	Number identifying the site from which the core was retrieved. A site is the position of a beacon around which holes are drilled.
	hole	Letter identifying the hole at a site from which a core was retrieved or data were collected.
	Core	Sequential numbers identifying the cores retrieved from a particular hole. Cores are generally 9.5 meters in length, and are numbered serially from the top of the hole downward.
	core_type	A letter code identifying the drill bit/coring method used to retrieve the core.

	time_on_deck	Timestamp when core was retrieved and brought on deck.
	entry_timestamp	Timestamp of entry into system.
	meter_comp_depth	Meters composite depth. Offset added to depth calculations for the core. Calculated based on all holes in area. Used to bring all cores at site to common depth.
	marine_tech_code	Code of marine technician entering core information into system.
	marine_tech_comments	Comments regarding core entered by marine tech.
	ops_tech_comments	Comments regarding core entered by ops tech.
	advancement	Meters that the core barrel advanced. Advanced can be more than 9.5 meters in cases of washed cores.
	top_depth	MBSF to top of core - comes from drillers. This is measured by drill string.
	is_pump1	Y or N was pump 1 used.
	is_pump2	Y or N was pump 2 used.
	wireline_runs	Number of wireline runs to recover the core.
	wireline_spool	Wireline spool used - F - fore, A - aft
	drilling_time	Drilling time in minutes.
	cc1	Type of the first core catcher used on a core barrel.
	cc2	Type of the second core catcher used on a core barrel.
	cc3	Type of the third core catcher used on a core barrel.
	shoe1	Type of the first shoe used.
	shoe2	Type of the second shoe used.
	shoe3	Type of the third shoe used.
	core_liner	Type of liner used for a core.
	orientation_tool	Type of orientation tool used with the core.
	offset	Time zone offset from Greenwich Mean Time (GMT). The values range from -12 to 12 where east of GMT is positive and west is negative.
	ops_pri_lith	Primary lithology of the core as described by rigfloor operations, not scientific lithologic description.
	ops_sec_lith	Secondary lithology of the core as defined by rigfloor operations, not scientific lithologic description.
	bit_id_null	Unique bit ID number, may be null

Appendix II. Descriptions of data items from Downhole Temperature query

Item Name	Column Description	Format
Leg	Number identifying the cruise. The ODP started numbering the scientific cruises of the <i>JR</i> at Leg 101. A leg was nominally two months duration. During the 18+ years of the ODP, there were 110 cruises on the <i>JR</i> .	Integer 3
Site	Number identifying the site. A site is the location where one or more holes were drilled while the ship was positioned over a single acoustic beacon. The <i>JR</i> visited 656 unique sites during the course of the ODP. Some sites were visited multiple times, including some sites originally visited during the Deep Sea Drilling Program for a total of 673 site visits.	Integer 4
Hole	Letter identifying the hole. Multiple holes could be drilled at a single site by pulling the drill pipe above the seafloor, moving the ship some distance away and drilling another hole. The first hole was designated 'A' and additional holes proceeded alphabetically at a given site. Location information for the cruise was determined by hole latitude and longitude. During ODP, there were 1818 holes drilled or deepened.	Text 1
Core	Cores are numbered serially from the top of the hole downward. Cored intervals are up to 9.7 m long, the maximum length of the core barrel. Recovered material was placed at the top of the cored interval, even when recovery was less than 100%. More than 220 km of core were recovered by the ODP.	Integer 3
Type	All cores are tagged by a letter code that identifies the coring method used.	Text 1
Top Depth (mbsf)	Depth in mbsf at top of core. Depth comes from drillers, drill string measurement.	Decimal F5.2
Bottom Depth (mbsf)	Depth in mbsf at bottom of core. Depth comes from drillers, drill string measurement plus advancement.	Decimal F5.2
Depth Comment	Depth in mbsf recorded by Marine Tech.	Decimal F7.3
Temperature (C)	Calculated temperature of core material, based on statistical fit of measured temperature data.	Decimal F6.3
Error (C)	Error in °C of calculated temperature.	Decimal F4.3
Mudline (C)	Temperature in °C measured at the seafloor.	Decimal F6.3
Tool Name	Name of the tool that was used to measure temperature.	Text 20
Notes	Comments about the temperature measurement.	Text 256